

Title: Importance of Disinfection on Arsenic Release in Wells.

Project I.D.: DNR Project #172

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Background/Need: A perplexing groundwater problem currently facing Wisconsin and other states is the high concentration of arsenic found in some drinking water wells, particularly in wells from northeastern Wisconsin. Levels of arsenic in some drinking waters can exceed recommended safe levels, often by large amounts. Although complicated, oxidation/reduction reactions affecting naturally occurring sulfide-bearing minerals appears to be the mechanism of arsenic release. In dealing with the arsenic problem, several field observations prompted this study. The first was that some wells constructed according to Wisconsin Department of Natural Resources (WDNR) recommendations (minimizing borehole interactions of air, water and sulfides) still developed unacceptable arsenic levels. The second observation was that chlorine added to wells as a bacterial disinfectant often resulted in an increase in the arsenic levels in the well waters.

Objectives: This study was conducted to better understand the effect on arsenic levels from disinfection processes and to evaluate whether alternate disinfection techniques could minimize arsenic release.

Methods: Four different approaches were taken. First, a test well was subjected to different disinfection treatments and the effect on arsenic release was analyzed. Second, a survey of a large number of wells with arsenic problems was conducted and, in conjunction with existing data records for these wells, insights on disinfection processes was gleaned from this data. Third, the several wells with biofilm (biological encrustations) problems were treated with an acid surfactant followed by low dose chlorination to see the effect on arsenic release. Finally, several experiments were run to see whether arsenic could be leached from scale or pipe encrustations.

Results and Discussion: Results showed that disinfection practices generally caused a temporary increase in well water arsenic (probably from the disintegration or dissolution of biofilms/encrustations). Once flushed, however, arsenic levels were generally much lower. There was no indication that any of the disinfection practices evaluated caused sustained increases in arsenic in the well waters. While the role of biofilms or biological encrustations in concentrating or scavenging arsenic is not totally clear, it is probably associated with the process by which iron, sulfur and other elements are oxidized by bacteria. The oxidized forms then precipitate. Iron and arsenic correlations observed in this study suggest such an association. Since biofilm growth is a dynamic process involving build-up and decomposition of the mass,

arsenic may at times be released to the water. This may explain, at least in some instances, variable concentrations of arsenic measured in well water samples. The well survey showed that certain well drilling techniques, such as wash-rotary drilling and Bradenhead grouting, were associated with lower arsenic levels in wells. Whether the aquifer was confined or unconfined did not seem to affect arsenic levels.

Conclusions/Implications/ Recommendations: Well water disinfection practices generally caused (in wells susceptible to arsenic problems) a temporary increase in well water arsenic, probably from the disintegration or dissolution of biofilms/encrustations. However, upon flushing (several well volumes pumped out), arsenic levels generally decreased. There was no indication that any of the disinfection practices evaluated caused sustained increases in arsenic in the well water. Based on the overall results of the study, acid surfactant treatment of wells, followed by low dose chlorination is the recommended treatment approach in most situations. The acid surfactant treatment is recommended because of its effectiveness in controlling biofilms, which are believed to play an important role in the dissolution of mineral arsenic in many situations. Clearly, the chemical and hydrologic characteristics of a well can be complex and very site specific, but minimizing biofilm development through preventative maintenance programs appears to be a universally applicable recommendation. Because biofilms are most easily treated when discovered early, regular monitoring of wells for biofilm problems and prompt treatment is recommended.

Key Words: Groundwater, arsenic, disinfection, oxidation-reduction, iron, biofilm

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Final Report: A final report containing more detailed information on this project is available for loan at the Water Resources Institute Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.